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Howard Pedolsky
Ukram Industries

Samuel Thurston
Ukram Industries

Roland Gavrylov
Eco-Fridge Production Company

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Environmental Friendliness of Cryogenic Refrigeration Systems for Transported Product

Howard Pedolsky¹, Samuel Thurston², Roland Gavrylov³

¹Ukram Industries, President
Bethesda, Maryland, US

²Ukram Industries, Technical Director
Bethesda Maryland, US

¹ & ² Tel: (301) 280 3572 Fax: (301) 942-2734
e-mail: Ukram1a@aol.com

³Eco-Fridge Production Company, Chairman and Ukram Industries System Engineer
Kharkov, Kharkov Ukraine
Tel: (380) 572 587-480, Fax: (380) 572 587-481
e-mail: Konstantin@ecofridge.info

1. Abstract

There is a major environmental problem in place with all present commercial refrigeration systems used for transporting produce and other products requiring refrigeration.

N₂ conditioning is an innovative, cost effective and practical method for providing the required environment for transportation of food produce and other products, which have specific temperature demands. The system we have developed is totally environmentally friendly.

Over the last several years the practicality of such a system has been proven. The system developed has been successfully road tested by several major produce. It has received significant support from two major N₂ supply companies.

During the test period we have had to validate several salient features of our system:

- User friendliness
- Safety
- Economic competitiveness
- Environmental friendliness

In order to demonstrate the latter two features we had to consider the total system, including end-to-end production and ready availability of N₂. Production is defined as, not only the production of the Nitrogen Conditioning System (NCS) but also production of N₂.

To demonstrate the environmental friendliness we had to consider, not only the environmental friendliness of our NCS, but also the environmental friendliness of manufacturing and producing all of the materials and products, which go into manufacturing and operating our system. Figure 1 shows the functional configuration of the NCS on a trailer. This paper will focus on the environmental considerations of the total system.

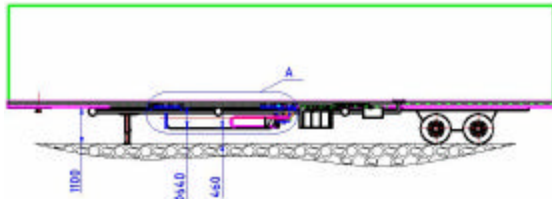


Figure 1. System configuration

2. Introduction

In recent times there has been a growing concern for the environmental effects of fossil and other fuels. Many studies have been made with very controversial results as to the actual contribution to the alteration of the environment various pollutants offer. Depending on the geographical location the sensitivity to the environment varies significantly, as well. However, it can be generally stated that if a product proves to be economically viable it would normally, today, be used in lieu of an existing system.

In order to verify the environmental effects of any system many factors must be considered. Some are obvious such as 'consideration of the by-products' of the system itself. Questions, which can readily be answered are:

- What are the gaseous by-products?
- Are there mechanized parts requiring fossil fuel operated motors?
- What are the working materials, themselves?

These and others like them are not difficult to discern. However, in order to really substantiate the environmental friendliness of a system it is necessary to go back to the production of all of the elements. How do they effect the environment? Do they contribute more to environmental pollution than the production of existing systems?

Following is a brief assessment of the total environmental effect of an LNG system such as the eco-Fridge NCS.

3. Discussion

3.1 Considerations

In order to discuss environmental impact of a system, the system must first be fully defined. The definition must include all aspects of the product, including:

- Raw material extraction and refinement
- Energy requirements at all levels
- Transportation requirements at each level
- Manufacturing
- Integration
- Installation
- Operation

Figure 2, below depicts the system as we see it.

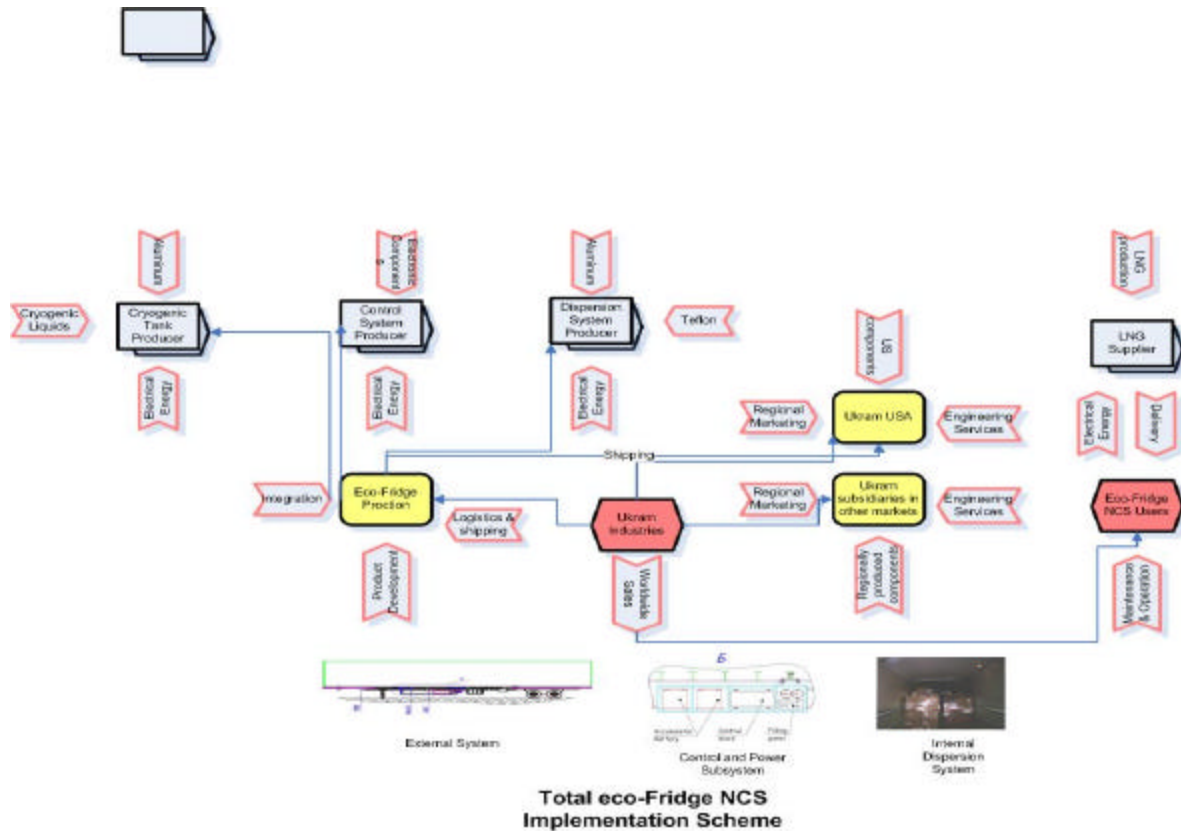


Figure 2

3.1.1 Electric Power

A significant factor, which is at almost every major step of the implementation scheme is the energy requirement. This requirement must be assessed very carefully. However, we must consider where the actual operation will be as to what environmental impact there will be. This consideration makes the impact much more difficult and much less clear. As an example, in the EU and Ukraine there is a significant emphasis on the use of nuclear power. The generation of nuclear power is very clean. However, the disposal of nuclear waste can be considered an environmental hazard. Hydroelectric power in California is environmentally clean. However fossil generated power is another issue unto itself.

In order to make a comparison with present refrigeration systems we must take into consideration similar contributors. Doesn't it take power to process HCFCs or their variants? Doesn't it take power to manufacture diesel parts, container parts, etc. Except for the inordinate power required for LNG production I feel power consumption is a clearly comparable in both processes. LNG production impact, however, must consider where it is being produced as stated above. In the EU it is probably a minimal impact. In California, it is also probably minimal. These are two areas where environmental impact is most scrutinized and seemingly of most concern. In Middle America, where fossil fuels are used more often at this time, LNG production is most likely a contributor to the environmental contamination. How much is arguable and will require further study.

3.1.2 Raw Materials

The NCS we have developed has two major raw materials, aluminum and Teflon. Aluminum is used in virtually all refrigeration systems in approximately the same quantities per system. Therefore, I can state we would negate the impact of aluminum. The tanks have a use life of over 20 years. We feel strongly that we can recycle the aluminum after the useful life is over and use it for further tank production or sell for other recycled products. Waste from production of tubes, sprayers and tanks are being recycled now in our production process. Teflon has very little impact. It is a carbonized material. Disposal of the material after we either remove it or from tube production waste is the major source of contamination. We use relatively small quantities of Teflon per system and the contribution of this to environmental contamination

is very small. There is no outgassing of the product. There is only the disposal issue. We will look at the possibility for recycle of this product.

Nitrogen in both gaseous and liquid form is totally environmentally benign. It is our most significant by product and we feel it is one, which has the least environmental impact. Almost all other refrigerants, including not only HCFCs and ammonia but CO₂ as well, contribute to environmental contamination at some level per both the Kyoto and Montreal Protocols.

3.1.3 Operations & Maintenance (O&M)

The impact of O&M can be significant. Mechanical systems have leakage of the HCFCs during operations and maintenance procedures. Disposal of the refrigerants is another problem. Diesel fuel exhaust is another source of CO₂ emission. Other environmental pollutants are oil residues from the diesel engines and lubricants. Another significant environmental disturbance is the noise generation from the mechanical systems. These must all be factored.

The eco-Fridge NCS has no motorized parts, no lubricants and no pollutant by products. There is no source of pollution emitted as a result of O&M. The N₂ gas released as a refrigerant and during the load is totally environmentally friendly.

3.2 Environmental Impact Assessment

The environmental considerations identified above must be assessed for their environmental impact. There are companies, which do this and actually rate the system based on all of the considerations identified. The rating, in our opinion, will vary per location of LNG production location. Other than that variable, the assessment should be consistent regardless of where the customer is located.

4. Summary

In summary we have identified those elements, which are building blocks towards a total environmental impact assessment. We anticipate very positive results but as stated it could vary with geographic location and method for producing electricity.

There are several actions, which must take place in the near future for those locations adhering to the Montreal or Kyoto protocols or variants of them. Further assessments of all refrigeration systems must be performed and comparative results should be mandatory. Of course, economic factors must be considered as well. The combined results should weigh significantly on where we proceed in the future.